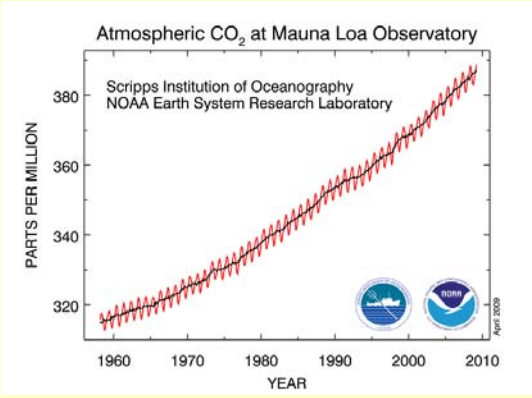
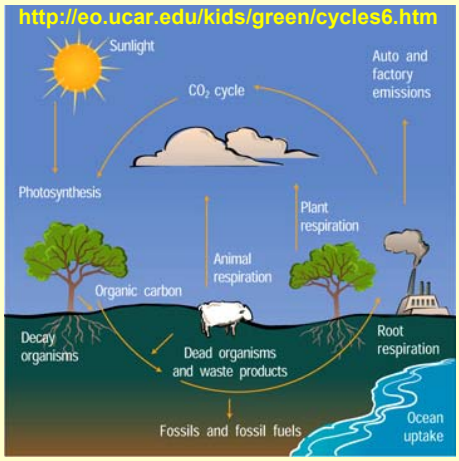
Soil-Profile Organic Carbon and Nitrogen during 12 Years of Pasture Management

Why does it matter?

- Carbon dioxide (CO_2) in the atmosphere has been increasing steadily during the past century. This is well documented by measurements in Hawaii since 1958 (initiated by Dr. Charles Keeling).
- Increasing CO_2 in the atmosphere is a concern, because of its potential to warm the planet. CO_2 and other greenhouse gases act as a barrier to prevent heat escaping from the atmosphere.
- Sequestration of soil organic carbon (C) and conservation of soil nitrogen (N) are of keen current interest to scientists, policy makers, agri-businesses, and landowners as a means of mitigating three important greenhouse gases [i.e. CO_2, methane (CH_4), and nitrous oxide (N_2O)].
- In the warm, humid region of the southeastern USA, pastures are recognized as an important land use capable of storing a large quantity of soil organic C and N.
- Although documentation is available for significant soil organic C sequestration in surface soil, very little research has been conducted on soil-profile (0-5') sequestration.





What was done?

- Our objectives were to (1) determine the rates of change in soil organic C and N at various depths within the soil during 12 years of management and (2) compare how nutrient source and forage utilization strategies might alter these rates.
- A 40-acre tract of private land managed by the USDA – Agricultural Research Service in Watkinsville GA was previously under row-crop cultivation and sprigged to 'Coastal' bermudagrass in 1992. 'Georgia' tall fescue was over-seeded in autumn 1999.
- Experimental paddocks (1.7-acre each) were replicated 3 times in a factorial arrangement of 12 treatments (3 nutrient sources x 4 forage utilization regimes). Nutrient sources were (a) inorganic only, (b) low broiler litter (1x supplemented with inorganic fertilizer), and (c) high broiler litter (3 times per year). Forage utilization regimes were (i) unharvested biomass (CRP), (ii) low grazing pressure, (iii) high grazing pressure, and (iv) hayed monthly.
- Soil samples were collected at initiation in April 1994, at the end of 5 years in February 1999, and at the end of 12 years in February 2006. Sampling depths were 0-6", 6-12", 12-24", 24-36", 36-48", and 48-60". Grazed paddocks were sampled in zones (a) near shade and water, (b) midway from shade/water, and (c) farthest from shade/water.

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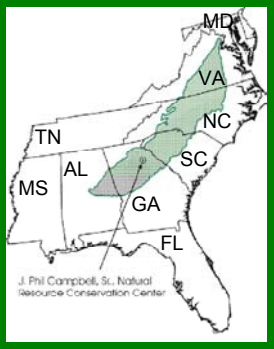

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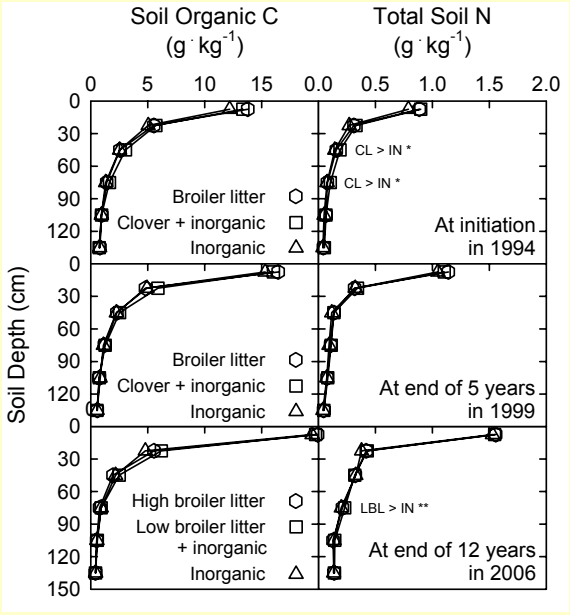
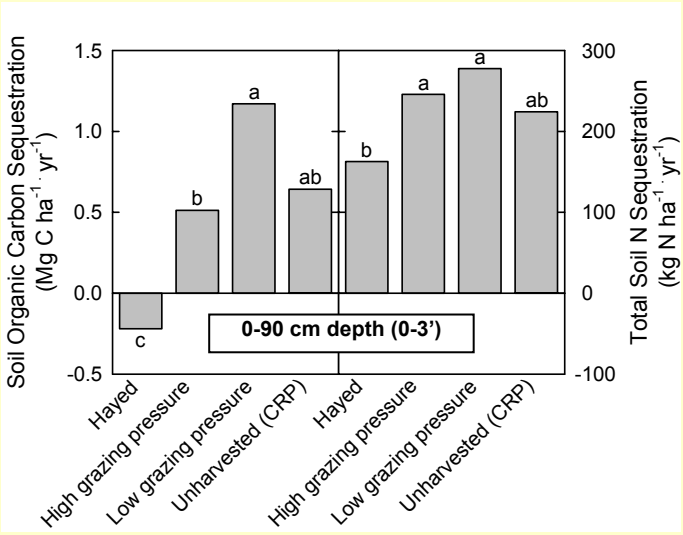
What was found?

- Soil organic C and N were highly stratified with depth, even at initiation of the study in 1994 (see set of 6 figures at upper right).
- Application of broiler litter led to sequestration of soil organic C of 1.10 ± 6.70 Mg C ha^{-1} at the end of 12 years. The mean value was not significantly greater than zero due to high random variation. Therefore, there was no evidence that manure application contributed to soil organic C sequestration, despite the high C input as manure (2.44 ± 0.60 Mg C ha^{-1} yr^{-1}).
- Soil organic C in the 0-6" depth at the end of 12 years was greater under grazed than under ungrazed management systems (20.7 vs 16.5 g C kg^{-1}) and was greater under unharvested than under hayed management (18.2 vs 14.8 g kg^{-1}).
- Below 6" of soil depth, no differences in soil organic C and N occurred among management systems at the end of 12 years.
- Significant soil organic C and N sequestration with time occurred only in the surface 6" of soil. Small declines in soil organic C with time occurred at depths below 12".
- Averaged across fertilizer sources, soil organic C sequestration to a depth of 3' was greatest under low grazing pressure, was intermediate under high grazing pressure, and was lowest under hayed management (see set of 2 figures at below-right).
- Total soil N changes were relatively similar to those for soil organic C, but only increases were observed with time. Greater N storage in soil suggests that fertilizer N applied remained in soil and was not lost.
- The loss of soil organic C below 12" depth with time appears to have occurred as a lag effect from historical cultivation prior to this experiment.
- Sequestration of soil organic C appears to only occur at the soil surface in pastures of the southeastern USA and not deeper in the soil profile as hypothesized.
- Animal loafing near shade/water increased organic C.





What is the impact?

- Farmers, scientists, and environmental specialists can benefit from this information to guide more effective sampling strategies and to acquire better estimates of soil organic C sequestration with cattle grazing systems.
- Assuming that the 34 million acres of pastureland in the southeastern USA were to sequester 0.46 Mg C ha^{-1} yr^{-1} (0.68 metric tons CO_2 equivalence per acre per year) to a 4-foot depth as observed in this study, a total of 6.3 Tg of C (25 tons of CO_2) could potentially be stored each year as a result of grass management in the region, a value of similar magnitude to that potentially stored if all cropland in the region were converted to no-tillage management.

For more information

Full-length article can be accessed at: www.sciencedirect.com/science/journal/01678809

Franzluebbers AJ, Stuedemann JA. 2009. Soil-profile organic carbon and total nitrogen during 12 years of pasture management in the Southern Piedmont USA. *Agriculture, Ecosystems and Environment* 129, 28-36.